PATENT
Atty Dkt. No. 040071-079

IMPEDANCE MATCHED HORN HAVING IMPEDANCE MATCHED TO IMPEDANCE OF AN EAR

TECHNICAL FIELD OF THE INVENTION

The present invention relates to an impedance matched horn and, more particularly, to an impedance matched horn having an impedance matched to an impedance of an ear.

BACKGROUND AND SUMMARY

Typically, radiotelephones include a main body having a receiver or speaker housed in an upper portion thereof and oriented to direct sound directly through an outer housing into the user's ear. The overall quality of speech and sound emitted by the receiver of a radiotelephone is sometimes referred to as speech intelligibility. It is an objective in devices such as radiotelephones to minimize size and weight without compromising speech intelligibility.

Speech intelligibility in radiotelephones is generally affected by a number of design factors including the receiver design, how and where the receiver is housed, and how the emitted sound energy is channeled to the ear. Ideally, a radiotelephone should produce a fairly level frequency response for a frequency range of approximately 300 Hz to 3000 Hz.

Factors such as interference from electrical components in radiotelephones presents restrictions on the design of receivers. U.S. Patent No. 5,963,640, the disclosure of which is incorporated by reference, discloses the use of an acoustical waveguide coupled to a speaker to permit mounting of the speaker at a point remote from sound ports that are intended to be placed proximate a user's ear and thus increase design flexibility. Nonetheless, receivers are designed in view of the impedance of free air, certain design features available in larger receiver systems such as loudspeakers and conventional telephones are not adapted to be used in receivers for radiotelephones. The impedance of free air necessitates that large volumes of air be moved to generate sufficiently intelligible sound. Accordingly, relatively large drivers are necessary to match the impedance of free air. This, in turn, presents limits in terms of the size, weight, and type of equipment that can be used, and how and where it can be located in a radiotelephone.

For example, although impedance matched horns matched to the impedance of the driver and free air are quite effectively used in large systems, the impedance of air requires such horns to be of sizes too great for use in smaller devices such as radiotelephone receivers. While various prior art radiotelephone devices, such as those disclosed in U.S. Patent No. 5,915,015, U.S. Patent No. 5,832,079, and WO98/51122, the disclosures of which are incorporated herein by reference, disclose the use of horns in connection with microphones, providing impedance matched horns in these devices must necessarily involve matching impendence with the impedance of free air as the speaker's mouth is typically held at a distance

from the mouthpiece apertures. Accordingly, providing a horn arrangement in such devices presents a restriction on the size of the radiotelephone. U.S. Patent No. 5,832,079 discloses that acoustic reciprocity dictates that the disclosed combination of an impedance matched horn and microphone is equally applicable to routing of output sound from interiorly mounted electromagnetic transducers to an output acoustic horn. However, such a horn and transducer would be of substantial size, just like the disclosed horn and microphone.

The present invention solves problems associated with prior art systems through the inventor's recognition that impedance of free air is not necessarily an appropriate design factor for consideration in radiotelephones. More particularly, the present invention relates to the inventor's discovery that, in receivers, it may be appropriate to match impedance of a horn to impedance of the driver and impedance of a user's ear instead of matching impedance to impedance of free air. This discovery results in permitting substantially smaller impedance matched horns and drivers than were previously known. Because the size of receivers including drivers and impedance matched horns can be substantially reduced according to the present invention, radiotelephone design flexibility is substantially improved, as the receivers are more easily isolated from potentially interference-causing components, and the weight and size of radiotelephones can be reduced. Further, speech intelligibility need not be compromised and may be enhanced through the use of a receiver including a horn having impedance matched with the impedance of an ear.

In accordance with one aspect of the present invention, an acoustic horn has an acoustic impedance matched with impedances of an ear and a driver.

In accordance with another aspect of the present invention, an electroacoustic transducer includes a driver and an acoustic horn having an acoustical impedance matched with impedances of an ear and the driver.

In accordance with yet another aspect of the present invention, a portable device includes a body, a driver mounted inside the body, and an acoustic horn having an acoustical impedance matched with impedances of an ear and the driver, a large end of the horn extending to a position proximate an exterior surface of the body.

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BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the present invention are well understood by reading the following detailed description in conjunction with the drawings in which like numerals indicate similar elements and in which:

FIG. 1 is a perspective view showing a radiotelephone device according to an embodiment of the present invention;

FIG. 2 is a perspective, partially broken view showing the radiotelephone device of FIG. 1 partially broken fashion to illustrate components of an electroacoustic transducer according to the present invention; and

FIG. 3 is a perspective view showing another portable device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A portable device 21 according to an embodiment of the present invention is shown in FIGS. 1 and 2. The device 21 includes a body 23, a driver 25 mounted inside the body, and an acoustic horn 27. The horn 27 has an acoustical impedance matched with impedances of an ear and the driver 25. A large end 29 of the horn 27 extends to a position proximate an exterior surface 31 of the body 23. A plate 33, which is preferably simply part of the body 23, is preferably disposed proximate the large end 29 of the horn 27 and has one or more, preferably a plurality of holes 35 therein. The plate 33 assists in preventing external objects from being inserted in or falling into the horn 27. The horn 27 may be separate from the body 23 or may be integrally formed with the body, such as by being formed upon molding of a plastic body.

The driver 25 preferably includes a driving membrane 37. The driver 25 is preferably quite small, preferably on the order of 2 mm x 1 mm x 5 mm overall, although the driver may be larger or smaller as desired or necessary. The driving membrane 37 is also preferably quite small, preferably on the order of 1 mm or less in diameter, although larger or smaller driving membranes may be used as desired or necessary. For example, the driving membrane 37 may be on the order of 2 mm, 3 mm, 4 mm, 5 mm, etc., as desired or necessary. A preferred embodiment of the driving membrane 37 is circular but the driving membrane may be of any suitable shape, such as square, triangular, oval, etc., as desired or

necessary. The horn 27 is preferably also quite small, and is preferably on the order of 5 mm tall, 1 mm thick, and 3-4 mm wide at its widest dimension. The horn 27 may be of many different sizes and shapes. For example, the horn 27 may have a cross-sectional shape that is circular, oval, square, triangular, rectangular, or some combination of shapes, such as a polygon having flat side walls and curved top and bottom walls. The horn 27 may be substantially straight, such as is seen in FIG. 3, may be curved along its length, such as is seen in FIG. 2, or may have some other suitable shape along its length.

The horn 27 in combination with the driver 25 defines an electroacoustical transducer which will also on occasion be referred to generally as a receiver. The horn 27 is preferably designed to match the impedance of the driver 25 and the impedance of a user's ear, i.e., with the large end 29 of the horn or the plate 31 sealed against the ear or nearly sealed against the ear. The design of the horn 27 may be established using suitable instrumentation such as the Wideband Ear Simulator for Telephonometry - Type 4195, available from Brüel & Kjaer, DK-2850 Nærum, Denmark.

According to the embodiment shown in FIG. 1, the body 23 forms at least part of a telephone device, preferably a radiotelephone device. The radiotelephone device can be provided with other features conventional in radiotelephone devices such as a flip cover 39 into which a user is intended to speak and which is preferably provided with apertures 41 leading to a microphone 43. A horn 45, preferably an impedance matched horn, can be provided between the apertures 41

and the microphone 43. U.S. Patent No. 5,915,015, U.S. Patent No. 5,832,079, and WO98/51122 disclose horn arrangements in radiotelephone devices of types suitable for use in connection with the present invention and are incorporated by reference.

Other conventional features of the radiotelephone device can include a display unit 47, a control key section 49 with user-actuated key surfaces disposed in a key surface plane, and an antenna 51. Cellular phone units readily adapted for incorporating the unique features provided by the present invention are available in various model numbers from Ericsson Inc, Research Triangle Park, North Carolina, and Telefonaktiebolaget L M Ericsson, Stockholm, Sweden.

By providing an impedance matched horn 27 according to the present invention in a receiver, it is possible to reduce the size of components used in radiotelephone receivers and other devices possessing receivers without compromising speech intelligibility. Moreover, the small size of the components used in the receiver according to the present invention facilitates arranging components in a portable or other device such that electrical interference between components is minimized. Further still, the small size of the components used in the receiver according to the present invention provides structural design flexibility not previously available in portable and other devices.

FIG. 3 shows an alternative embodiment of the present invention wherein the body 121 has an elongated shape. The body 121 may form at least part of a device such as a writing instrument, such as a pen or pencil. Apertures 35 can be

provided in a side of the body 121 or, if desired or necessary, in an end of the body. It will be appreciated that an electroacoustic transducer according to the present invention can be incorporated into a number of different structures as desired. Other structures into which an electroacoustic transducer according to the present invention might be incorporated include personal computers, wireless devices such as pagers or so-called personal digital assistants or PALMPILOTs, and the like. Of course, if desired or necessary, the electroacoustic transducer according to the present invention can be incorporated into large devices, and is not limited to application in smaller devices of the type listed above.

While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.